Thank you for the review of our manuscript. We appreciate your constructive comments and suggestions. Please find our point-by-point response below (in blue).
In general, we have identified the following main issues, which we have addressed below:

1) We found the method section related to a description of the HBV model (structure, routines, parameters) too brief and we will describe it in more detail.

2) We will be more explicit about the data used for model calibration and simulation. In particular, we will clarify how the discharge, glacier mass balance and snow data have been used to model calibration and evaluation

3) We will better explain how the runoff components are calculated in the model and how to interpret the results related to the inter-annual variability of the components and explain the contradiction between the snowmelt which contributes most to the total runoff and glacier-melt which controls the inter-annual variability.

4) We agree that more emphasis should be placed on a literature review and discussion related to understanding the runoff process in polar areas and its impact on terrestrial ecosystems.

Overall, this manuscript is within the scope of the journal and adds some significant contributions to our understanding of the water budget and runoff processes on the Antarctic Peninsula. As I understand it, this paper is about quantifying the various contributions from snow, glacial melt, and rain to streamflow on the Antarctic Peninsula, and the relationships of total runoff and runoff contributions to climate variations. However, the title only mentions snow and glacial contributions but the paper also addresses rain contributions as well. There is also some confusion with the various study periods for the different model components as well as the field validations and measurements. The methods section needs more detail on the model: how the model uses the input data and how it estimates many of the simulated values, and also the field validation methods and what exactly was measured and how it was used. The discussion section also needs to be expanded in order to elaborate on the importance of the results and the implications for the ecosystems in this region and the effects of climate on runoff processes.

Specific comments

The title only mentions snow and glacial contributions but the paper also addresses rain contributions as well.

When formulating the research questions, we were interested mostly in snow and glacier contributions since the rainfall is rather minor. However, we agree that the original title might be confusing, so we have decided to change the title accordingly to "The role of snowmelt, glacier melt and rainfall in streamflow dynamics on James Ross Island, Antarctic Peninsula"

1. ABSTRACT AND INTRODUCTION:

Lines 13-14: It would be helpful to actually state what the total study period is (i.e. June 2010 – May 2021).

We agree that this change might improve readability. We will reformulate the respective text to "We used the hydrological model HBV to simulate the runoff process from June 2010 to May 2021 at a daily resolution."

Lines 17: What does "strong glacier and snow melt" mean?

We found the word "strong" to be too vague and redundant in the sentence. We will remove it from the text.

Lines 25: What are "high air temperatures in recent years"? Can this be quantified above average or above previous maximum temperatures?

We agree that the text is too vague. We will rephrase it to "Although the warming of this region was interrupted in the early part of the 21st century (Turner et al., 2016; Oliva et al., 2017), the cooling period ended in the mid-2010s and (Carrasco et al., 2021) since then the region has experienced several warm events with record high temperatures (González-Herrero et al., 2022)."

Line 40: It may be helpful to also note that all of the precipitation in the dry valleys is in the form of snow (whereas the peninsula also receives some rain, analyzed in this paper).

We will add the note to the text: "In addition, this region receives a certain amount of precipitation in the form of rain, unlike the Dry Valleys where only snowfall was observed (Fountain et al., 2010)."

Line 55 and Line 62: It would be helpful to include some description of the terrestrial and marine environments in these regions in relation to streamflow and how they are affected by these runoff processes. What is the importance of understanding runoff processes for these ecosystems and environments?

The description of the impact of changes in terrestrial ecosystems on streamflow is stated in L30-35. However, we will do more literature search on the topic and extend this part accordingly.

Lines 66: Again the study period of 2010/2011 – 2020/2021 is confusing. It may be helpful to state that streamflow only occurs during XX months, so the study covers the time period of June 2010 – May 2021 or something along those lines…

We agree and we will reformulate the text to "… water balance components from June 2010 to May 2021 based on available climate …"

1. METHODS:

Lines 86-87: How much of the precipitation is estimated to come from rainfall and from snow each year? Has this changed over time?

As previously stated on L106, numerical models represent the only available source of information about precipitation from a long-term perspective in the study area. However, data from three stations located west of the Antarctic Peninsula Carrasco and Cordero, (2020) indicate an increase in precipitation from 1970 to the early 1990s, followed by a decrease from 1991 to 1999. Additionally, an increase in snowfall and a decrease in rainfall were observed from the mid-1990s to the mid-2010s, resulting from the cooling period. We will consider adding this information to the text.

Lines 70 and on… Some further discussion of the streams where discharge is being measured would be helpful. How much does the discharge vary from year to year? What is the average flow season? Is runoff only estimated at one location/stream?

Indeed, in such remote areas, the water level is not possible to measure continuously over longer periods. Further uncertainties arise from discharge calculation using rating curves which need to be created separately for each year due to the riverbed changes. Usually, the discharge data is only available from a few locations around the polar station and only during its operation (usually one to two months each year). For our study area of the Triangular catchment, the only available measurements cover the time period from February to March 2018 which was used as one of the variables for the HBV model calibration (see the respective lines 149-152 of the original manuscript). Therefore, neither the inter-annual variability nor the length of the discharge season are known. However, based on your comment, we decided to extend the discussion on the above topic.

Line 99: Why was 1 June estimated as the start of the water year?

After a careful literature search, we are not aware of any systematically used definition of the hydrological year in this area. Therefore, we determined the beginning of the hydrological year based on our data. We have chosen June as the beginning because (based on our dataset) from that month onwards the number of days with precipitation and air temperature above 0 °C is negligible.

Line 99: Were air temp and total precip the only inputs for the model? How does it use those to estimate runoff and glacier mass balance?

The model inputs are formed by air temperature (T), precipitation (P) and potential evapotranspiration (PET; calculated using air temperature). Available data of glacier mass balance and runoff was used for model calibration. The whole procedure is described in section 2.3. However, we now realized that the model description is probably not fully clear and some important details are missing (e.g. the better description of snowmelt and glacier routines), although references to detailed model descriptions are provided in the original text. We have decided to substantially extend the methods section to better explain how the model deals with input data and how the individual water balance components are calculated.

Lines 106: Was there any field validation for the simulated precipitation?

Yes, there was a field validation of the simulated precipitation. We will add the following text to the respective section: “Short-term precipitation measurements were taken in January and February 2022 at the Johann Gregor Mendel Station using a Thies laser precipitation monitor (disdrometer) and a manual rain gauge. These data were used to validate the performance of the Weather Research and Forecasting (WRF) model (Matějka et al., 2022).”

Lines 116: Why was the runoff only calculated from Feb – Mar 2018? Was there no other data outside this period? How did this period relate to the rest of the study period?

Please also see our response to one of your similar comments above. There was no other measured discharge data in the study catchment outside this period. We are aware that this period represents only a small part of the entire study period and this was one of the reasons why we used glacier mass balance measurements for model calibration. As noted above we will extend the discussion section related to the topic with a new paragraph (also related to your comment on lines 304-305).

Lines 120: What is the “glaciological method”?

We will extend the text as follows: The seasonal surface mass balance of Triangular Glacier was estimated using a glaciological method, spatial interpolation of melt and accumulation measured at ablation stakes, once a year for the years 2014/15–2019/20.

Lines 120-21: Why was surface mass balance only estimated for 2014-2020? These study periods don’t match up across the entire study and needs to be addressed.

The mass balance measurements were only carried out in 2014-2020. In combination with the volume measurements in 2006 and 2015, we were able to simulate the mass balance for the whole study period (L121-124). Please see also our answer to your comment about Lines 304 – 305.

Lines 125- 127: The section on snow depth needs more detail -- was snow depth only measured at one location? How was it extrapolated across the catchment? Is the snow on the glacier the only thing assumed to contribute to runoff? What about snow in the rest of the catchment? Was SWE/snow density measured as well?

Snow depth was only measured at one site. This data was not used to calibrate the model. It was only used as an additional check that the model simulated a realistic snow cover. No SWE measurements are available from this area.

We will modify this section as follows: “Snow depth was measured using a sonic distance sensor (Judd Communication, USA) fixed at the automatic weather station located in the central part of Triangular Glacier during the period 6 February 2017 to 23 January 2020. The zero point level was chosen arbitrarily (Engel et al., 2023). The snow depth was only used to calculate the estimated SWE, which was calculated as the observed snow depth multiplied by constant density 389 kg·m-3 which was the mean measured density in summer season 2022. The estimated SWE time series was only used for model evaluation”.

Additionally, we will replace “snow density” with “estimated SWE” throughout the manuscript.

Lines 132: model routines need to be defined. Were all of these routines used? Or was one chosen from these 5?

All of these routines were used since only together they can calculate the water propagation through the entire system and simulate the runoff in the outlet. As we noted in the response to one of your comments above, we realized that the model description, despite referenced literature, is not fully clear and some important details are missing. We have decided to extend the methods section substantially to better explain how the model deals with input data and how the individual water balance components are calculated.

Lines 146: Why was this section not considered in the model?

Unfortunately, no measurements of the mass balance from this area are available. However, the small part of the ice cap is located in the highest part of the catchment. Therefore, we can assume that this part does not contribute with glacier-melt water to runoff and thus can be technically considered as “glacier-free” in the model (which contributes only by occasional snowmelt to the total runoff as explained on L328-331 in the original manuscript). This our assumption was later supported by model results where no glacier melt was simulated above approximately 350 m a.s.l. We will consider reformulation of the existing text both in methods and discussion for clarity.

Lines 155-165: The runoff is reported in mm, but I assume it was measured in some rate (i.e. l/s). How was this rate converted to mm and why? Was it summed up over the daily, monthly, yearly period?

Yes, the streamflow (in $m^3 s^{-1}$) was calculated from direct water level measurements using a rating curve. However, it is a common (a good) praxis in hydrology and hydrological modelling to report streamflow as runoff depth (the term “runoff” is frequently used), which is a water volume per unit area (usually catchment) for a defined period (daily, monthly, annual) or a long-term mean (therefore the units are mm). Among others, this approach enables the direct comparison of all measured and simulated water balance components (precipitation, PET, snow, glacier, soil and groundwater storage) available in the same units.

We will go throughout the whole text to ensure that all values and their sums (daily to annual or a mean) are always clearly reported and named by correct terminology.

1. RESULTS:

Lines 168 -171: These values could be put into a table to show the overall model fit.

As stated in the methods, we performed 100 calibration runs to address equifinality and increase the model robustness. The range of the objective function values is shown in Fig. A1. We will consider of creating a simple table showing the median values which are now presented only in the main text. Furthermore, we will fix the typo (S1 to A1) and move the reference to the second sentence of this paragraph where it makes more sense.

Lines 176-177: Glacier mass balance simulation and observed should be included in Figure 2.

When writing manuscript, we decided to move some of the plots showing the model performance in the appendix. This also covers the comparison of simulated and observed mass balance which we placed as Fig. A2 in the original manuscript. However, we will consider putting all these plots directly into the results section.

Lines 179-180: There was never a mention of SWE or snow density measurements in the methods. How was simulated SWE compared to snow depth? How did the model estimate SWE and snow depth? This needs a lot more detail in the methods and results.

We refer to our response to your comment on Lines 125- 127 above. Additionally, we will add the following text to the respective section: “During validation, mean simulated SWE in the elevation zone, in which the weather station is located was compared to estimated SWE.”

Figure 3: The cumulative line in (a) should be a color that is easier to see (or does this line really need to be there?). The axes also need more values, especially at 0 in (a) to see mass loss or gain.

We agree, we will modify the image to make it easier to read.

Lines 197: the glacier did not melt at all? Might be more appropriate to say "did not lose mass" as there was likely still some melt generated on the glaciers even if they did not lose mass.

We will rephrase the sentence as you suggested.

Lines 198: Are these simulated SWE values? SWE measurements were never addressed in the methods section so I'm unsure if these values are from the model or measurements. If they are from the model, this needs to be added to the methods section of how the model calculates and estimates SWE.

These are simulated SWE values. We will add (to the method section) that measured SWE was only used for model evaluation. Please also see our previous response to your related comments above.

Lines 202: What does it mean "these months accounted for 32% and 25% of the total SWE loss"? This needs to be explained more and likely shown in a figure.

We agree that this specific result is not sufficiently described and might be confusing. Instead of this, we will consider adding a new figure or table showing the fraction of the mean monthly snowmelt on the mean annual snowmelt. Please see also a simple plot showing the values (we will improve the visual look and clarity of the plot if we decide to include it in the revised version).

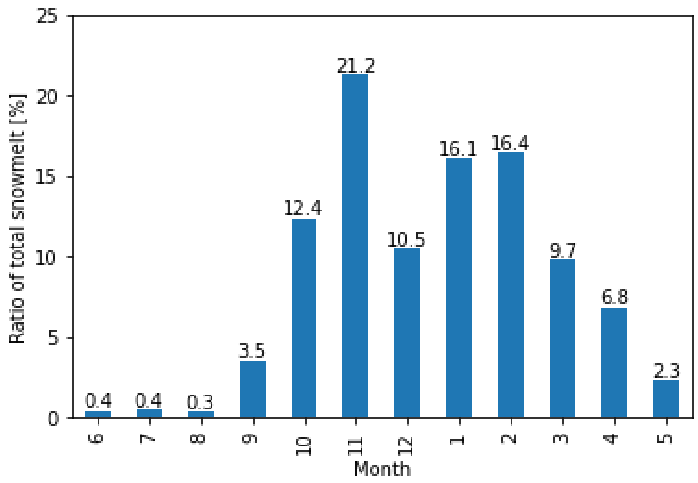

Fig. Mean monthly snowmelt fractions to the mean annual snowmelt

Lines 204: The simulated mean runoff was 415 mm? Should this be 415 mm per year?

As stated in the sentence, we refer to "mean annual runoff".

Lines 204-205: What were the instances when there was runoff outside of the main summer season? When did this winter runoff occur? This is brought up in the abstract and conclusion and needs much more attention in the results and discussion.

We agree that this particular result is not well addressed in the discussion section. We will add the following text to the discussion to clarify this issue: "According to Kavan et al., (2023) seven studies have been devoted to measuring runoff in the Antarctic Peninsula area between 1991 and 2020(Inbar, 1995; Kavan et al., 2017; Sziło and Bialik, 2017; Falk et al., 2018; Stott and Convey, 2021; Kavan, 2021; Kavan et al., 2023) For most of the studies, the duration of the measurements did not exceed two months. Only one study (Stott and Convey, 2021) measured for 78 days. The measurements were mostly made during January and February, sometimes also in March. Only one study (Stott and Convey, 2021) covered most of December. However, no study took measurements during September, October, November or May. Therefore, our results, which include 11 years of simulated daily runoff, provide valuable information, although they are subject to the uncertainties of modelling based on small amounts of data."

Lines 205: How was evapotranspiration estimated? This was never mentioned before in the methods.

The method of calculation of daily potential evapotranspiration is mentioned on line 104. The actual evapotranspiration was calculated by the model as a function of simulated soil moisture and air temperature. We will provide a better description of the model routine along with other model routine descriptions as mentioned in our responses above.

Lines 206: It was never stated how much of the precipitation was estimated to come from snow vs. rain, or how the model partitions this. So how was the different contributions estimated between rain and snow in the model?

The HBV model is partitioning snowfall and rainfall using a concept of a single threshold temperature (T_T). The T_T is one of the model parameters calibrated by the model. Since the catchment is divided into elevation zones, the precipitation phase is then calculated separately for the specific elevation zone using a calibrated temperature lapse rate. Further, the model keeps track of whether the water comes from rain or snowfall (or glacier melt) throughout the other model components until leaving the catchment, assuming the complete mixing of water in individual components (so-called effect tracking; Weiler et al., 2018).

Similar to your comments and our responses above, we will include better explanation of precipitation partitioning along with more detailed description of model structure and parameters.

Figure 4: The axes should be colored for each of the values they are representing, it is confusing as is. Also, these should be split into two panels so that the various y axes don't overlap. Precip and temp should be panel A with only one y-axis on each side. Panel B below should be Q and cumulative Q.

We will modify the image to make it easier to read.

Figure 5: can these bars be stacked to add up to total Q instead of being side by side? That will make it easier to see how the allocation of various Q contributions changes.

Thank you for the suggestion. We tried to redesign the figure following the reviewer's suggestion, but we believe that the original form is clearer and allows easier comparison between runoff components between months. Nevertheless, we will try to find other solutions to increase readability and select one we will consider as best.

Figure 6: Similar to Fig. 5 these figures are confusing and have too many axis values. It would be beneficial to split into panels so that the axes labels do not overlap.

We will modify the image to make it easier to read.

Line 247: is this referring to snow cover on the glacier that melted out earlier?

Yes, we will rephrase the sentence for clarity.

Line 276: I am confused how Qglacier can be the only one significantly correlated with Q total, and how it can have the dominant control over total runoff, but Qsnow dominates the proportion of total runoff (over 75%)? This needs more in depth analysis and thought into what this means in both the results and discussion section.

Of the three runoff components, annual $Q_{glacier}$ has the highest inter-annual variability (see the table below). This is because it is more dependent on annual temperature than Q_{snow} and Q_{rain}. For snow, as an example, it means that there is a similarly equal amount of snow in individual years, which results in low inter-annual variability of snow runoff contribution even though it is a dominant component of the total runoff. Therefore, the inter-annual variations of the total runoff are dominantly caused by inter-annual variations in glacier-melt runoff rather than snowmelt runoff.

We agree that the text in the original manuscript is not fully clear in this respect, therefore we will reformulate it.

Table: Coefficient of variation for the individual runoff components

Annual Q	Annual Q_{rain}	Annual Q_{snow}	Annual $Q_{glacier}$
0.15	0.53	0.16	0.79

Figure 9: It is hard to see the solid vs dotted circles, may want to make the outlines bigger or different colors.

Thank you for the suggestion, we will modify the image to make it easier to read.

1. DISCUSSION:

Lines 304 – 305, should address **the discrepancies in study periods for all of the data and how this may affect the interpretation of results**.

Thank you for the comment. Besides better clarification of the input data and time periods in the methods section (as mentioned above), we will add the following text to the discussion section:

“It must be noted that the model calibration and simulation were carried out on different data sets, which, except for air temperature, precipitation and PET, did not cover the whole study period. The streamflow measurements were only taken during one summer season (8 February–15 March 2018) and may not fully represent the variability of streamflow during the whole study period. The mass balance measurements were carried out in 2014-2020, which in combination with the glacier volume measurements in 2015/16 gave us sufficient information for the model calibration period. However, the volume of Triangular Glacier at the start of the simulation in 2009 was estimated from a digital elevation model of the ice surface of Triangular Glacier in 2006, assuming a constant change in glacier extent of -0.3% per year as stated in (Engel et al., 2023) as the mean annual retreat rate between 2006 and 2014. For this reason, the uncertainty of the initial state of the glacier was introduced into the simulation.”

Lines 316: Where did these percip measurements come from? From the methods, I thought that there were no precip observations so this needs to be addressed earlier. Are there measurements of both rain and snow?

We agree that the respective section might be confusing. Therefore, we will add the following text to the method section: “Short-term precipitation measurements were taken in January and February 2022 at the Johann Gregor Mendel Station using a Thies laser precipitation monitor (disdrometer) and a manual rain gauge. These data were used to validate the performance of the Weather Research and Forecasting (WRF) model (Matějka et al., 2022).”

Lines 326: So SWE was measured? Needs to be brought up in methods.

Please see our answers to your comments on Lines 125-127 and Lines 179-180.

Lines 331: I thought this part was not considered in the model at all, but now it is saying that snow from this area was considered? Why is this? This needs to be explained more.

We will rephrase the text in methods so it is clear that the highest part of the catchment is considered as glacier-free area in the model. Please, see also our response related to your comment on Line 146.

Lines 333 – 334: The statement “the glacier is covered with snow most of the year preventing any potential glacier melt” needs to be backed up. How does snow prevent glacier melt? Is there data to show that the glacier is actually covered with new snow most of the year? If there is no data or references to back this up than this statement needs to be removed.

Thank you for the comment. After reviewing our text we decided to remove the respective sentence since it is not necessary.

Lines 349 – 350: What are the different definitions of the start year? Why was June 1 chosen for this study?

Thank you for the comment. After reviewing our text we decided to remove the respective sentence since it is not necessary. Additionally, we will reformulate the whole section for clarity.

Lines 351-355: Why is this statement worth mentioning? If the authors feel that this is important to mention then this needs to be explained and elaborated on further here.

We agree that this sentence is not necessary. We will remove it.

Lines 364-365: It is also important to note that the flow season for streams in the McMurdo Dry Valleys is much shorter than on the Peninsula, and most of the streamflow comes from glacial melt.

Thank you for the suggestion, we will reformulate the text as follows: "The reason for this finding may be that the total precipitation amount is lower compared to our study area, resulting in lower snow accumulation on glaciers and thus its earlier melt-out, causing the earlier initiation of glacier melt, which is the primary source of runoff. It is important to note that the flow season in the McMurdo Dry Valleys is shorter than that observed in the study area, with an average length of 70 days (Gooseff and Lyons, 2007)."

Lines 370: AP?

We will change it to "Antarctic Peninsula"

Lines 371 -372: The statement "this in turn may cause water shortages and affect local freshwater ecosystems" can be explained much more. How does water availability in these areas affect the ecosystems? Why is it important to study the runoff regimes of these areas for the environment and ecosystems? This needs references and elaboration to back it up.

Thank you for the comment. We will consider reformulating the whole section in lines 371-376 and include more references to make it more informative.

Lines 373-374: How does rising temperatures influence suspended sediment transport? And what does this mean for this study? This section of the discussion needs to be expanded on quite a bit for the broader environmental implications.

Thank you for the comment. We will consider reformulating the whole section in lines 371-376 and include more references to make it more informative.

Lines 376: Again, needs more expansion on the idea that higher amounts of rainfall can affect melting of snow and glaciers. How? And why is this important? Need references to back this idea up.

Thank you for the comment. We will consider reformulating the whole section in lines 371-376 and include more references to make it more informative.

CONCLUSIONS:

Line 391 – 392: the statement: "Together with mean annual evapotranspiration (7 mm) and mean annual precipitation (369 mm)." is not a complete sentence, maybe combine it with the previous sentence.

Thank you for pointing out that. We will correct the sentence.

Lines 396: Again, what does "strong glacier and snow melt" mean?

We agree that the word “strong” is too vague and redundant in the sentence. We will remove it from the text.

Lines 398-399: as stated before, I am confused how Qglacier can be the only control on total annual Q, but Qsnow is the main contributor to Qtotal. This needs to be clarified in the discussion and if stated in the conclusion then it needs to be explained more.

Please see our response to your comment on Line 276. We will reformulate the sentence for clarity.

Lines 404-405: The presence of runoff-generating events outside of the summer season was not addressed in detail in the discussion section, and if it is going to be included in the conclusion and abstract it needs much more attention and analysis outside of the brief mention in results.

Please see our response to your comment on Lines 204-205. We will also consider reformulation here for clarity.

References

Carrasco, J. F. and Cordero, R.: Analyzing Precipitation Changes in the Northern Tip of the Antarctic Peninsula during the, 2020.

Weiler, M., Seibert, J., and Stahl, K.: Magic components—why quantifying rain, snowmelt, and icemelt in river discharge is not easy, Hydrol. Process., 32, 160–166, https://doi.org/10.1002/hyp.11361, 2018.